

What is claimed is:

- 1 1. A method of determining a placement of services of a distributed application
2 onto nodes of a distributed resource infrastructure comprising the steps of:
3 a. forming communication constraints between node pairs which ensure that
4 a sum of transport demands between a particular node pair does not exceed a
5 transport capacity between the particular node pair, each term of the sum
6 comprising a product of a first placement variable, a second placement
7 variable, and the transport demand between the services associated with the
8 first and second placement variables;
9 b. forming an objective; and
10 c. employing a local search solution to solve an integer program comprising
11 the communication constraints and the objective, which determines the
12 placement of the services onto the nodes.

- 1 2. A method of determining a placement of services of a distributed application
2 onto nodes of a distributed resource infrastructure comprising the steps of:
3 a. establishing an application model of the services comprising transport
4 demands between the services;
5 b. establishing an infrastructure model of the nodes comprising transport
6 capacities between the nodes;
7 c. forming an integer program that comprises:
8 i. a set of placement variables for a combination of the services and the
9 nodes, each of the placement variables indicating whether a particular
10 service is located on a particular node;
11 ii. communication constraints between node pairs which ensure that a
12 sum of the transport demands between a particular node pair does not
13 exceed the transport capacity between the particular node pair, each term
14 of the sum comprising a product of a first placement variable, a second
15 placement variable, and the transport demand between the services
16 associated with the first and second placement variables; and
17 iii. an objective; and
18 d. employing a local search solution to solve the integer program which
19 determines the placement of the services onto the nodes.

- 1 3. The method of claim 2 wherein the step of solving the integer program
2 employs a local search solution.
- 1 4. The method of claim 2 wherein the objective comprises minimizing
2 communication traffic between the nodes.
- 1 5. The method of claim 2 wherein the application model further comprises
2 processing demands for the services.
- 1 6. The method of claim 5 wherein the infrastructure model further comprises
2 processing capacities for the nodes.
- 1 7. The method of claim 6 wherein the integer program further comprises
2 processing constraints which ensure that a sum of the processing demands for
3 each of the nodes does not exceed the processing capacity for the node.
- 1 8. The method of claim 7 wherein the objective comprises minimizing
2 communication traffic between the nodes and balancing the processing demands
3 on the nodes.
- 1 9. The method of claim 6 wherein the processing demands and the processing
2 capacities are normalized according to a processing criterion.
- 1 10. The method of claim 9 wherein the processing criterion comprises an
2 algorithm speed.
- 1 11. The method of claim 9 wherein the processing criterion comprises a
2 transaction speed.
- 1 12. The method of claim 9 wherein the processing capacities of the nodes are
2 found according to a look-up table in which different types of nodes have been
3 normalized according to the processing criterion.

- 1 13. The method of claim 2 wherein the application model further comprises
2 storage demands for the services.
- 1 14. The method of claim 13 wherein the infrastructure model further comprises
2 storage capacities for the nodes.
- 1 15. The method of claim 14 wherein the integer program further comprises
2 storage constraints which ensure that a sum of the storage demands for each of the
3 nodes does not exceed the storage capacity for the node.
- 1 16. The method of claim 2 wherein the integer program further comprises
2 placement constraints which ensure that each of the services is placed on one and
3 only one of the nodes.
- 1 17. The method of claim 2 wherein the services reside on the nodes according to a
2 previous assignment.
- 1 18. The method of claim 17 further comprising the step of assessing reassignment
2 penalties for service placements that differs from the previous assignment.
- 1 19. The method of claim 18 wherein the integer program further comprises a
2 second objective that seeks to minimize the reassignment penalties.
- 1 20. A method of determining a placement of services of a distributed application
2 onto nodes of a distributed resource infrastructure comprising the steps of:
3 a. establishing an application model of the services that comprises processing
4 demands for the services, storage demands for the services, and transport
5 demands between the services;
6 b. establishing an infrastructure model of the nodes that comprises processing
7 capacities for the nodes, storage capacities for the nodes, and transport
8 capacities between the nodes;
9 c. forming an integer program that comprises:
10 i. a set of placement variables for a combination of the services and the
11 nodes, each of the placement variables indicating whether a particular

- 12 service is located on a particular node;
- 13 ii. processing constraints which ensure that a sum of the processing
- 14 demands for each of the nodes does not exceed the processing capacity for
- 15 the node;
- 16 iii. storage constraints which ensure that a sum of the storage demands for
- 17 each of the nodes does not exceed the storage capacity for the node;
- 18 iv. placement constraints which ensure that each of the services is placed
- 19 on one and only one node;
- 20 v. communication constraints between node pairs which ensure that a
- 21 sum of the transport demands between a particular node pair does not
- 22 exceed the transport capacity between the particular node pair, each term
- 23 of the sum comprising a product of a first placement variable, a second
- 24 placement variable, and the transport demand between the services
- 25 associated with the first and second placement variables; and
- 26 vi. an objective of minimizing communication traffic between the nodes
- 27 and balancing processing loads on the nodes; and
- 28 d. employing a local search solution to solve the integer program which
- 29 determines the placement of the services onto the nodes.

- 1 21. A computer readable memory comprising computer code for directing a
- 2 computer to make a determination of a placement of services of a distributed
- 3 application onto nodes of a distributed resource infrastructure, the determination
- 4 of the placement of the services onto the nodes comprising the steps of:
- 5 a. forming communication constraints between node pairs which ensure that
- 6 a sum of transport demands between a particular node pair does not exceed a
- 7 transport capacity between the particular node pair, each term of the sum
- 8 comprising a product of a first placement variable, a second placement
- 9 variable, and the transport demand between the services associated with the
- 10 first and second placement variables;
- 11 b. forming an objective; and
- 12 c. employing a local search solution to solve an integer program comprising
- 13 the communication constraints and the objective, which determines the
- 14 placement of the services onto the nodes.

- 1 22. A computer readable memory comprising computer code for directing a
2 computer to make a determination of a placement of services of a distributed
3 application onto nodes of a distributed resource infrastructure, the determination
4 of the placement of the services onto the nodes comprising the steps of:
- 5 a. establishing an application model of the services comprising transport
6 demands between the services;
 - 7 b. establishing an infrastructure model of the nodes comprising transport
8 capacities between the nodes;
 - 9 c. forming an integer program that comprises:
 - 10 i. a set of placement variables for a combination of the services and the
11 nodes, each of the placement variables indicating whether a particular
12 service is located on a particular node;
 - 13 ii. communication constraints between node pairs which ensure that a
14 sum of the transport demands between a particular node pair does not
15 exceed the transport capacity between the particular node pair, each term
16 of the sum comprising a product of a first placement variable, a second
17 placement variable, and the transport demand between the services
18 associated with the first and second placement variables; and
 - 19 iii. an objective; and
 - 20 d. employing a local search solution to solve the integer program which
21 determines the placement of the services onto the nodes.
- 1 23. The computer readable memory of claim 22 wherein the step of solving the
2 integer program employs a local search solution.
- 1 24. The computer readable memory of claim 22 wherein the objective comprises
2 minimizing communication traffic between the nodes.
- 1 25. The computer readable memory of claim 22 wherein the application model
2 further comprises processing demands for the services.
- 1 26. The computer readable memory of claim 25 wherein the infrastructure model
2 further comprises processing capacities for the nodes.

- 1 27. The computer readable memory of claim 26 wherein the integer program
2 further comprises processing constraints ensure that a sum of the processing
3 demands for each of the nodes does not exceed the processing capacity for the
4 node.
- 1 28. The computer readable memory of claim 27 wherein the objective comprises
2 balancing the processing demands on the nodes.
- 1 29. The computer readable memory of claim 26 wherein the processing demands
2 and the processing capacities are normalized according to a processing criterion.
- 1 30. The computer readable memory of claim 29 wherein the processing criterion
2 comprises an algorithm speed.
- 1 31. The computer readable memory of claim 9 wherein the processing criterion
2 comprises a transaction speed.
- 1 32. The computer readable memory of claim 9 wherein the processing capacities
2 of the nodes are found according to a look-up table in which different types of
3 nodes have been normalized according to the processing criterion.
- 1 33. The computer readable memory of claim 22 wherein the application model
2 further comprises storage demands for the services.
- 1 34. The computer readable memory of claim 33 wherein the infrastructure model
2 further comprises storage capacities for the nodes.
- 1 35. The computer readable memory of claim 34 wherein the integer program
2 further comprises storage constraints which ensure that a sum of the storage
3 demands for each of the nodes does not exceed the storage capacity for the node.
- 1 36. The computer readable memory of claim 22 wherein the integer program
2 further comprises placement constraints which ensure that each of the services is
3 placed on one and only one of the nodes.

1 37. The computer readable memory of claim 22 wherein the services reside on the
2 nodes according to a previous assignment.

1 38. The computer readable memory of claim 37 further comprising the step of
2 assessing reassignment penalties for service placements that differs from the
3 previous assignment.

1 39. The computer readable memory of claim 38 wherein the integer program
2 further comprises a second objective that seeks to minimize the reassignment
3 penalties.

1 40. A computer readable memory comprising computer code for directing a
2 computer to make a determination of a placement of services of a distributed
3 application onto nodes of a distributed resource infrastructure, the determination
4 of the placement of the services onto the nodes comprising the steps of:
5 a. establishing an application model of the services that comprises
6 processing demands for the services, storage demands for the services, and
7 transport demands between the services;
8 b. establishing an infrastructure model of the nodes that comprises processing
9 capacities for the nodes, storage capacities for the nodes, and transport
10 capacities between the nodes;
11 c. forming an integer program that comprises:
12 i. a set of placement variables for a combination of the services and the
13 nodes, each of the placement variables indicating whether a particular
14 service is located on a particular node;
15 ii. processing constraints which ensure that a sum of the processing
16 demands for each of the nodes does not exceed the processing capacity for
17 the node;
18 iii. storage constraints which ensure that a sum of the storage demands for
19 each of the nodes does not exceed the storage capacity for the node;
20 iv. placement constraints which ensure that each of the services is placed
21 on one and only one node;
22 v. communication constraints between node pairs which ensure that a

23 sum of the transport demands between a particular node pair does not
24 exceed the transport capacity between the particular node pair, each term
25 of the sum comprising a product of a first placement variable, a second
26 placement variable, and the transport demand between the services
27 associated with the first and second placement variables; and
28 vi. an objective of minimizing communication traffic between the nodes
29 and balancing processing loads on the nodes; and
30 d. employing a local search solution to solve the integer program which
31 determines the placement of the services onto the nodes.